

Clinical Use of Synthetic Arterial Substitutes in Three Hundred Seventeen Patients

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In recent years increasing interest has been devoted to the direct surgical treatment of various forms of aortic and arterial disease. In general, three principles of therapy have been developed, namely, excision with restoration of normal continuity, the by-pass procedure, and thromboendarterectomy. The indications for each of these procedures is dependent upon the nature and extent of the disease. Although the value and efficacy of these methods of therapy have now become well established, there remain certain problems in their practical application. These are concerned particularly with the first two methods, in which a vascular replacement is required. The significance of this problem is well illustrated by our own experience. Thus, during the six-year period since the adoption of these methods of therapy we have employed some form of vascular replacement in approximately 1000 cases. In the great majority of these, more than three-fourths of the cases, homografts have been employed for this purpose. Both technically and functionally they have provided highly gratifying results.^{6,8} Some of these have been studied grossly and histologically as long as three years postoperatively, and little significant structural change has occurred during this

time. Thus, the homograft has been generally considered to be the most satisfactory available arterial substitute.

The primary disadvantage of arterial homografts is the inconvenience associated with their procurement and preparation. The technical and legal factors involved in the procurement, preparation, and preservation are such that homografts are not available in sufficient quantity to meet the needs in many communities. Moreover, with extension of the life span of the general population, there will be an increasing demand for vascular replacements. Heterografts derived from the sheep, cow, pig, and horse, and preserved by conventional methods, have been studied experimentally^{3,4} and employed clinically, but have been found to be unsatisfactory, owing to their rapid deterioration and their tendency to aneurysm formation. The obvious solution to this problem lies in development of an ideal synthetic replacement for this purpose. Accordingly, we, like others actively interested in this problem, have been concerned with development and application of suitable synthetic substitutes. During the past three years we have replaced 317 segments of the aorta and peripheral arteries with one of six synthetic materials. This report is concerned with analysis of this experience.

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Material and Method

The synthetic materials used in these cases were Ivalon (polyvinyl formalized) sponge, Orlon fabric, Orlon knit, nylon-Dacron knit, Edwards-Tapp tube, and Dacron knit (Table 1). Since the essential features of most of these materials have

TABLE 1.—Distribution of Cases of Synthetic Tube Replacement According to Location and Type of Lesion

Type	Location and Type of Lesion						Total
	Thoracic Aorta		Abdominal Aorta {		Peripheral Arteries		
	Aneurysm	Occlusive Disease	Aneurysm	Occlusive Disease	Aneurysm	Occlusive Disease	
Ivalon	7	1	7	0	0	5	20
Orlon fabric (taffeta)	0	0	11	2	0	0	13
Orlon knit	0	0	12	2	0	2	16
Nylon-dacron knit	12	0	30	2	0	0	44
Edwards-Tapp	0	3	70	34	3	105	215
Dacron knit	1	0	5	0	1	2	9
Total	20	4	135	40	4	114	317

been presented elsewhere,¹¹⁻¹⁵ only those not included in these reports, as well as those that have been adapted for our own purposes, will be described in detail.

Ivalon.—Prosthetic tubes of compressed Ivalon sponge for replacing segments of the aorta and peripheral arteries were made in our laboratory. A loaf of the sponge was soaked in warm water for 48 hours and dried in an x-ray film drier for 24 hours. The dried sponge was sliced into sheets approximately 2 mm. in thickness, and these were cut into strips 2.5 cm. wide. These strips were then soaked in warm water and wrapped on the appropriate mold. The sponge was held in place around the mold with a wrapping of gauze bandage, and it was then placed in the regular operating-room autoclave. After 20 minutes, the sterilizer was allowed to cool without exhausting the steam. A combination of heat, moisture, and pressure exerted by the gauze produced a compressed tube that could be

withdrawn from the mold without altering its shape. With use of glass molds, tubes could be made for replacement of any desired segment of the major arterial system. Ivalon tubes constructed in this manner were employed in 20 cases for the treatment of aneurysms and occlusive lesions of the aorta (Fig. 1) and peripheral arteries (Table 1).

Orlon Fabric.—To make these tubes, Orlon cloth was cut and sewed on the sewing machine according to the desired pattern. The tubes were then drawn over a mandrel and coated with vinyl plastic in order to ensure maintenance of shape and prevention of excessive leakage through the interstices of the cloth. To sterilize the tubes, they were soaked in an aqueous solution of benzalkonium (Zephiran) chloride. These bifurcated tubes were employed in 13 cases to replace excised segments of the abdominal aorta for aneurysms and occlusive lesions (Table 1 and Fig. 2).

Fig. 1.—Photograph taken at operation showing a bifurcated tube made of compressed Ivalon sponge replacing the distal aorta and proximal segments of the common iliac arteries.



Fig. 2.—Photograph taken at operation showing a tube made of Orlon taffeta dipped in vinyl plastic replacing the distal aorta and common iliac arteries.





Fig. 3.—Photograph at operation showing a nylon-Dacron knitted tube replacing the distal aorta and common iliac arteries.

Orlon Knit.—Seamless bifurcated knitted Orlon tubes* were used to replace segments of the distal aorta and common iliac arteries in 14 patients, 12 of whom had aneurysms and 2 arteriosclerotic occlusive lesions of the distal aorta and iliac arteries. This material was also used to by-pass peripheral arteriosclerotic occlusive lesions occurring in the external iliac artery of one patient and the superficial femoral artery of another (Table 1).

Nylon-Dacron Knit.—The essential features and construction of bifurcated tubes made of knitted nylon-Dacron† suitable for replacement of the aorta and common iliac arteries have been described by Sanger and associates.¹⁴ Lesions of the thoracic aorta were replaced with segments of this tube in 12 patients. The distal aorta and segments of the common iliac arteries were replaced with this material in 32 patients, 2 of whom had occlusive lesions and 30 aneurysms (Table 1 and Fig. 3).

Edwards-Tapp Tube.—The crimped woven, chemically treated nylon tubes developed by Edwards and Tapp,¹² secured from the local dealer, were used to restore circulation in the surgical reconstruction of 215 lesions of the aorta and peripheral arteries (Table 1). Bifurcated tubes of this type were employed in the treatment of aneu-

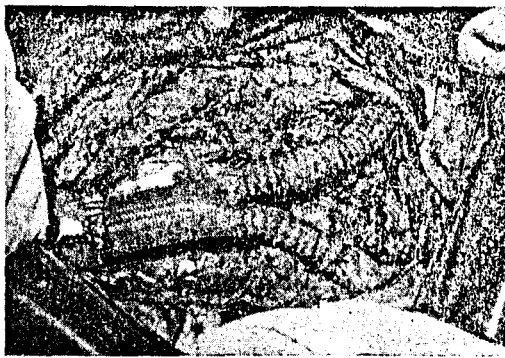


Fig. 4.—Photograph at operation showing a crimped woven nylon tube replacing the distal aorta and common iliac arteries.

rysms and occlusive lesions of the abdominal aorta in 104 cases and of the innominate artery of one patient (Fig. 4). Occlusive lesions in the thoracic aorta of 3 patients, the iliac arteries of 12 patients, and the femoral arteries of 92 patients were either replaced or by-passed with long straight tubes made of this substitute (Fig 5). Similar tubes were also used to replace two aneurysms of the femoral artery and one occurring in the popliteal artery.

Dacron Knit.—Knitted tubes of 490-denier Dacron were recently devised by us in cooperation with the Philadelphia Textile Institute.⁵ This tube is made flexible by proper crimping and application of heat over a mandrel at 200 C for 10 minutes. Tubes made of this material have been employed in nine patients; one had an aneurysm of

Fig. 5.—Photograph at operation showing the distal anastomosis of a crimped woven nylon tube with the popliteal artery by-passing an occlusion of the superficial femoral artery. The desired flexibility for this technique is well demonstrated.



* Made available through the courtesy of Dr. Paul Sanger, Charlotte, N. C.

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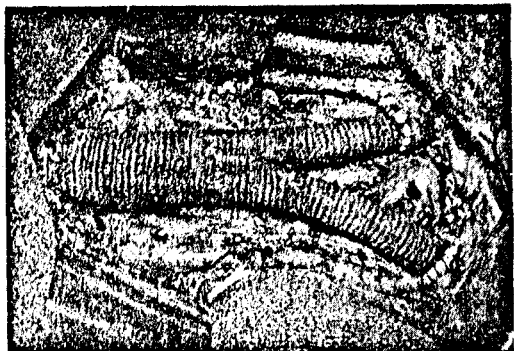


Fig. 6.—Photograph at operation showing a new flexible knitted Dacron tube replacing the distal aorta and common iliac arteries.

the thoracic aorta; five, aneurysms of the abdominal aorta (Fig. 6), and one, an aneurysm of the popliteal artery (Table 1). Arteriosclerotic occlusive lesions of the superficial femoral artery were by-passed in two patients with use of this synthetic material (Figs. 7 and 8).

Technique of Application

To reduce porosity of the tubes, all substitutes except those made of Ivalon or Orlon fabric were preclotted in the patient's blood prior to insertion. The fibers at the ends of the Edwards-Tapp tubes were fused with a cautery to minimize fraying. This was not a problem with the other materials; consequently, the other tubes were cut and beveled with scissors. Bleeding around the sutures and through the fabrics after insertion, and immediately after restoration of circulation, was controlled by application of pressure with gauze packs. Aneurysms, regardless of their location, were removed and replaced in all instances. Occlusive lesions of the aorta were treated by a variety of techniques. In some patients they were completely excised and replaced; in others they were treated by both replacement and by-pass, and in the remainder they were by-passed. In all occlusive lesions limited to the iliac or superficial femoral arteries an end-to-side by-pass technique was employed. These synthetic substitutes were inserted according to the techniques for insertion of homografts previously described, whereby

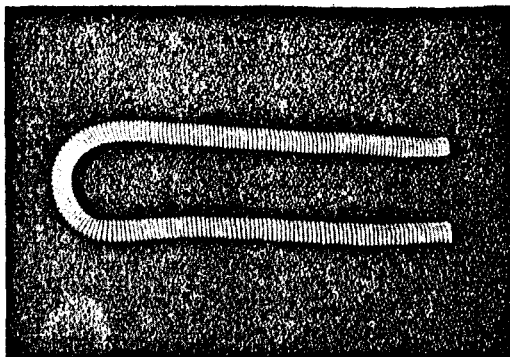


Fig. 7.—Photograph showing a new long, flexible, nonfraying knitted Dacron tube suitable for lesions of the peripheral arteries.

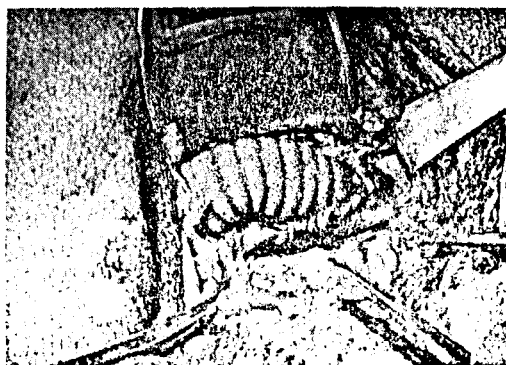
the anastomosis is accomplished by use of a simple continuous over-and-over, through-and-through suture which approximates host tissue and replacement.^{1,2,7,9,10}

Results

The results of application of synthetic substitutes in this series of patients varied according to the material used and the site in which it was inserted; consequently, each of these factors will be considered separately (Tables 2-4).

Aorta.—The early functional results of all replacement grafts used in the thoracic aorta of patients who survived operation were satisfactory, and results are still good at this writing. The immediate results in the use of these substances in replacing lesions involving the abdominal aorta and

Fig. 8.—Photograph at operation showing the distal anastomosis between the new flexible knitted Dacron tube and the popliteal artery. The tube was used in this case to by-pass an occlusion of the superficial femoral artery.



SYNTHETIC ARTERIAL SUBSTITUTES

TABLE 2.—Results* of Synthetic Replacement for Lesions of the Abdominal Aorta

Replacement	Aneurysm			Occlusive Disease			Total		
	Successful Results			Successful Results			Successful Results		
	No. Cases	No.	Per Cent	No. Cases	No.	Per Cent	No. Cases	No.	Per Cent
Ivalon	7	5	71	0	0	0	7	5	71
Orlon fabric (taffeta)	11	10	90	2	1	50	13	11	85
Orlon knit	12	12	100	2	2	100	14	14	100
Nylon-dacron knit	30	30	100	2	2	100	32	32	100
Edwards-Tapp	70	69	98	34	33	97	104	102	98
Dacron knit	5	5	100	0	0	0	5	5	100
Total	135	131	97	40	38	95	175	169	96

* Total results (early and late) up to three years after operation.

the common iliac arteries were also good in all cases but one, in which circulation was not restored in the left iliac artery after replacement of an occlusive lesion of the distal aorta with an Orlon taffeta tube (Table 2). Subsequent failure to maintain circulation occurred in 5 of the 175 patients in whom these substitutes had been inserted for lesions of the abdominal aorta and iliac arteries. Two of these late failures were in patients in whom the Edwards-Tapp tube had been used. False aneurysms developed at the suture line four and six weeks, respectively, after operation. Eventual removal of the tube was required in one patient, and the extremity had to be amputated. One of the thirteen patients in whom an Orlon taffeta tube had been inserted at this level died approximately six months after operation of hemorrhage associated with erosion into the duodenum. Late failure occurred in two of the seven patients in whom Ivalon tubes had been inserted in the abdominal aorta and common iliac arteries. One of these failures occurred six months after operation and was due to kinking of the iliac limbs of the tube that occurred after wound closure and healing.

Failure in the other patient was due to infection that became apparent three weeks after operation.

Peripheral Arteries.—The margin of safety in restoring circulation by any method is smaller in operations on small arteries than in those on larger vessels, such as the aorta. Greater technical precision is required, and the lumen of the vascular substitute must fit more precisely that of the host vessel. The end-to-side by-pass technique of inserting these substitutes in the treatment of peripheral occlusive lesions has been generally found to be the most satisfactory method of operation. In order to apply this technique successfully and to permit motion across articular spaces, a certain degree of flexibility of the substitute is necessary. A number of inflexible substitutes were used in vessels of this size in experimental animals with the by-pass technique. As the results were generally poor, only seven such replacements (five Ivalon and 2 Orlon knit tubes) were employed clinically (Table 1). Six of these tubes (five Ivalon and one Orlon knit) were used to by-pass occlusive lesions of the femoral artery, but as a result of early thrombosis

TABLE 3.—Results* of Synthetic Replacement for Lesions of the Peripheral Arteries

Replacement	Aneurysm			Occlusive Disease			Total		
	Successful Results			Successful Results			Successful Results		
	No. Cases	No.	Per Cent	No. Cases	No.	Per Cent	No. Cases	No.	Per Cent
Ivalon	0	0	0	5	0	0	5	0	0
Orlon knit	0	0	0	2	1	50	2	1	50
Edwards-Tapp	3	3	100	105	92	87	108	95	88
Dacron knit	1	1	100	2	2	100	3	3	100
Total	4	4	100	114	95	83	118	99	84

* Total results up to one year after operation.

TABLE 4.—*Analysis of Failures of Synthetic Replacement of Peripheral Arteries in 118 Patients**

Replacement	No. Cases	Failure		Cause			
		Number	Per Cent	Physical Limitation of Substitute	Patient's Disease	Technique	Infection
Edwards-Tapp	108	13	12	0	7	2	4
Ivalon	5	5	100	5	0	0	0
Orlon knit	2	1	50	1	0	0	0
Dacron knit	3	0	0	0	0	0	0
Total	118	19	16	6	7	2	4

* Total failures (early and late) up to one year after operation.

circulation was not maintained in any of these cases (Table 3). Sterile abscesses requiring removal of the tube also developed around the Ivalon tubes in three patients, and in one patient the distal anastomosis (popliteal) pulled apart four weeks after operation. Circulation was successfully restored by insertion of an inflexible Orlon knitted tube that by-passed an occlusive lesion of the iliac artery of one patient.

The Edwards-Tapp and the recently designed Dacron knitted tubes are flexible and available in varying lengths and dimensions. Because of these desirable characteristics and their obvious applicability, proved by trial in the laboratory, these tubes were considered suitable for clinical application. During the past year the Edwards-Tapp tube has been used as replacement following excision of aneurysms in 3 cases and to by-pass occlusive lesions in the peripheral arteries in 105 cases—1 in the innominate, 12 in the iliac, and 92 in the superficial femoral arteries (Table 1). The criteria for selection of patients and the technique of insertion of these substitutes were identical with those used for homografts.² There were 13 failures in this group (Table 4). Of the 12 patients in whom this tube was inserted to by-pass iliac occlusions, 1 died of a severe wound infection (synergistic bacterial gangrene); however, a pulsatile circulation was restored beyond the occlusion in 10 patients. The tube, which extended from the left common iliac artery to the right popliteal artery, by-passing a right ilio-femoral occlusion, became occluded in one patient six months after operation. Exploration of the popliteal artery in this case

revealed that late failure had been due to progression of the atherosclerotic process occurring in this segment. Of the 92 patients in whom Edwards-Tapp tubes had been inserted to by-pass lesions of the femoral arteries, 1 died of pulmonary embolism, and a distal pulsatile circulation was immediately restored in 86 patients (93%). Failure of restoration of circulation in six patients was due to infection, in one, and to an inadequate distal patent segment, in five (Table 4). The unfavorable nature of the distal segment was suspected before operation in these cases. Operation was performed in an attempt to relieve the severe ischemic changes present in the involved extremities, since occasional successful restoration of circulation had been accomplished by this technique in such cases. A distal pulsatile circulation has been maintained up to one year in 82 of the 86 patients (95%). Failure of maintenance of circulation occurred in four patients after they left the hospital. This was due to thrombosis in three patients (one from infection, one from extension of atherosclerotic process in the popliteal artery, and one from an unknown cause). Failure in the fourth resulted from wound infection and hemorrhage one month after operation. Circulation was successfully restored and maintained in the three patients in whom peripheral aneurysms were excised and replaced by this material.

The recently designed flexible Dacron knitted tube has been used in two patients to by-pass occlusive lesions in the femoral artery and in one to replace a popliteal aneurysm, with successful restoration of circulation in both.

Comment

The functional results in this series of cases, with the exception of those in which Ivalon and Orlon fabric were used, approximate those obtained with homografts and suggest that homografts could be satisfactorily supplanted by these materials (Table 2). However, certain functional and technical disadvantages still must be overcome if these substitutes are to be equally as acceptable as homografts. In the first place, the amount of blood lost at the time of operation when these materials were employed was frequently more than twice that lost when homografts were used. This may be a significant factor in the occurrence of a higher morbidity and mortality following use of synthetic materials than following use of homografts. Thus, wound infection was not a problem in the 150 patients with peripheral lesions treated by homografts, whereas of 118 patients in whom synthetic materials were inserted for peripheral lesions, suppurating wound infection occurred in 4. The mortality rate in 70 patients having aneurysms of the abdominal aorta replaced with bifurcated Edwards-Tapp tubes was 10%. In view of the age of these patients and the incidence of heart disease, hypertension, and rupture of the aneurysm, this mortality figure is acceptable. However, in the last consecutive 70 patients with abdominal aortic aneurysms in whom homografts were inserted there were no deaths. This discrepancy in mortality rates may be more apparent than real, although the increased incidence of wound infection and the higher mortality rate in these patients tend to emphasize the undesirability of the excessive hemorrhage associated with their use.

Synthetic vascular substitutes have another disadvantage. Certain physical characteristics limit their adaptability to specific problems and make their insertion more difficult. The undesirable physical characteristics of the substitutes used in the present study varied. Unfortunately, no one synthetic material possessed all desirable characteristics of a satisfactory substitute, although some



Fig. 9.—Photograph at operation showing a crimped woven nylon tube replacing the distal aorta and common iliac arteries and a small bifurcated iliac artery homograft replacing the bifurcation of the right common iliac artery.

were more suitable than others. The high degree of success obtained in this series of patients was due to the early recognition of the limitations posed by a particular substitute and the fact that it was used only under those circumstances. The lack of accessory branches for use in replacing segments of the aorta or common iliac arteries from which essential major branches originate was a limiting factor in the use of all prosthetic material. Although this need is relatively uncommon, such branches have required replacement in more than 30 patients in our experience (Fig. 9). In order to discuss the individual limitations of the substitutes employed in these cases, they will be considered separately or in groups as indicated.

Orlon Fabric (Taffeta).—The tubes made of Orlon taffeta and coated with vinyl plastic are semirigid, a characteristic that increases technical difficulties of insertion and renders the tube unadaptable to problems requiring even minimal flexibility. Because of this and the disadvantages common to all substitutes, these tubes are no longer recommended.

Ivalon.—Properly constructed Ivalon tubes possess enough flexibility to provide reasonable ease of insertion, but not enough to permit general use if considerable flexibility is required. Thrombosis of the tube occurred six months after operation in one

patient in whom an excised aneurysm of the distal aorta and proximal segments of the common iliac arteries had been replaced with this material, although the requirements of satisfactory replacement seemed apparent at the time of operation. The graft was unsuccessful because of kinking of the iliac limbs of the tube; and review of the case after the second operation indicated that the tube was not kinked prior to closure of the wound, but, because of the relative inflexibility of the material and the irregularity of the aneurysmal bed, kinking occurred with closure, organization, and healing of the wound. The relative inflexibility of this material appeared to be partially responsible for its failure in operations on small arteries.

The occurrence of sterile abscesses along the course of three of these tubes several weeks after they had been inserted and had become obstructed by thrombosis makes us question the purity of the material used. The material originally contained formalin; however, a reasonable effort was made to wash out the formalin, and if it was unsuccessful, this failure must be regarded as a disadvantage of the material. Although aneurysms have not developed in these cases, we have observed aneurysms in two Ivalon tubes inserted elsewhere. One of these occurred in a bifurcated tube used to replace the distal aorta and proximal segments of the common iliac arteries. Aneurysm developed in the distal end of an aortofemoral by-pass Ivalon tube six months after operation in the other patient. Although our total experience with Ivalon tubes was limited to 20 cases, the relatively high failure rate, 35%, in this series of cases, along with its other disadvantages, led us to abandon its use.

Orlon Knit and Nylon-Dacron Knit.—These materials were employed primarily to replace localized segments of the aorta and common iliac arteries in instances in which flexibility was not a special requirement of the substitute. Restoration of circulation has been maintained in all instances. The results from use of similarly constructed smaller

tubes in the laboratory were generally poor; consequently, the smaller tubes were inserted in only two patients by the end-to-side by-pass technique. In one of these circulation was not restored, and this failure appeared to be due to rigidity of the tube.

The physical characteristics of this material are such that its technical insertion is as easy as that of homografts. The ends of the tube can be cut or beveled without fraying, despite considerable tension during performance of the anastomosis. The tubes are soft and collapsible; and since the edges can be rolled back, either row of the anastomosis can be performed unhindered. The resistance to passage of sutures exerted by this material is essentially the same as that of homografts. Bleeding through the interstices of this fabric is perhaps greater than through those of the other materials, despite preclotting in the patient's blood. In our cases considerable care was required, with intermittent removal and reapplication of the controlling clamps, until sufficient hemostasis had occurred. Within these limitations, Orlon knit and nylon-Dacron knit are considered to be satisfactory aortic substitutes.

Edwards-Tapp Tube.—The chemically treated nylon tube has several advantages over most of the materials used in these cases. In the first place, it is commercially available in unlimited supply, and, although the tube designed for replacing the distal aorta and common iliac arteries is available in only one size, the longer, straight tubes are available in several sizes, so that there is a reasonable degree of selectivity. A second desirable feature of this substitute is its flexibility, which permits a wide range of adaptability in regard both to the nature of the lesion and to its location.

In addition to excessive loss of blood at operation and lack of accessory branches, this tube has several relatively minor disadvantages. Cauterizing does not entirely prevent fraying, and, of course, the fire and explosive hazard associated with use of this technique is an obvious disadvantage. The aortic segment of the bifurcated tube is fre-

quently smaller than the aorta of patients with aneurysm. Because of the inconvenient uniformity of size and the rigidity of this segment of the tube, insertion is occasionally difficult to accomplish, particularly in the obese patient. This material has been generally satisfactory, however, and with continued improvement many of these objections can be overcome.

Dacron Knit.—The objective in the development of the Dacron knitted tube was to incorporate into the replacement the desirable characteristics of all other available substitutes. Being basically a knitted fabric, it has all the desirable technical characteristics of the Orlon and nylon-Dacron knitted tubes, and, by incorporation of flexibility and accessory branches into tubes of various shapes and sizes, a complete range of adaptability may be obtained. Preliminary results from its application, both in the laboratory and clinically, indicate that this may meet the ideal requirements.

Summary

Arterial homografts have been generally accepted as the most satisfactory arterial substitute, their primary disadvantages being unavailability and inconvenience of preparation. Efforts toward solving the problem of graft procurement have consequently been directed more and more toward development of a suitable synthetic replacement.

This report is concerned with observations derived from an analysis of a three-year experience with tubes made of Ivalon (polyvinyl formalinized) sponge, Orlon taffeta, knitted nylon-Dacron, knitted Orlon, crimped woven nylon, and knitted Dacron used to replace or by-pass aortic and peripheral arterial lesions in 317 patients.

Functional results of all replacements used in the thoracic aorta of patients who survived operation were satisfactory. Immediate results in lesions involving the abdominal aorta and common iliac arteries were also good in all cases but one, but late failures occurred in five patients.

Early failure occurred in the five patients in whom Ivalon tubes were used to by-pass peripheral occlusions. Circulation was restored in only one of the two patients in whom inflexible Orlon knitted tubes were used to by-pass peripheral occlusions, but was restored in all three patients in whom peripheral aneurysms were replaced by the Edwards-Tapp tube and in 92 of 105 patients in whom occlusive lesions were by-passed. The recently designed flexible Dacron knitted tube was used successfully in two patients to by-pass occlusive lesions in the femoral artery and in one to replace a popliteal aneurysm.

Although the functional results in this series of cases have been generally good, certain disadvantages still must be overcome in creating an ideal arterial replacement. The porosity of synthetic materials causes excessive blood loss, and the lack of accessory branches for replacing segments from which essential major branches originate has been a limiting factor in some cases. Tubes made of Orlon taffeta coated with vinyl plastic are difficult to insert and unadaptable to problems requiring even minimal flexibility. Ivalon tubes, though more flexible, are still too rigid for general use and in our series produced a relatively high failure rate of 35%. Orlon knitted and nylon-Dacron knitted tubes, when used to replace localized segments not requiring flexibility, restored and maintained circulation in all instances, and, within the limitation of their semirigidity, are satisfactory substitutes. The Edwards-Tapp tube is both flexible and adaptable, although its ends fray and insertion is sometimes difficult.

The recently devised knitted Dacron tube incorporates the desirable characteristics of all other available substitutes, and with the addition of accessory branches a complete range of adaptability may be obtained. Preliminary results of its application, experimentally and clinically, indicate that it is the best substitute yet developed.

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Addendum

Since this paper was presented, the new flexible knitted Dacron tube has been used exclusively as a vascular replacement in our experience with the last 237 cases. The results of this experience may be briefly summarized in the following analysis:

Thoracic aorta	
Aneurysms	23 cases with 6 deaths
Coarctation	7 cases with no deaths
Abdominal aorta	
Aneurysms	84 cases with 3 deaths
Occlusive disease	33 cases with 1 death
Peripheral arteries	
Aneurysms	15 cases with 1 death
Occlusive disease	75 cases with no deaths

There were no "graft failures" or complications attributable to the use of the graft. Normal circulation was restored in all the patients with aortic lesions and with peripheral arterial aneurysms who survived operation and in 95% of those with occlusive disease of the peripheral arteries. This experience involves application of the knitted Dacron tube to virtually all segments of the aorta and peripheral arteries, including those requiring multiple branches, such as the aortic arch and upper abdominal aorta. On the basis of this highly gratifying experience along with the technical facility of its application, we believe this knitted flexible Dacron tube is the most satisfactory available vascular replacement.

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